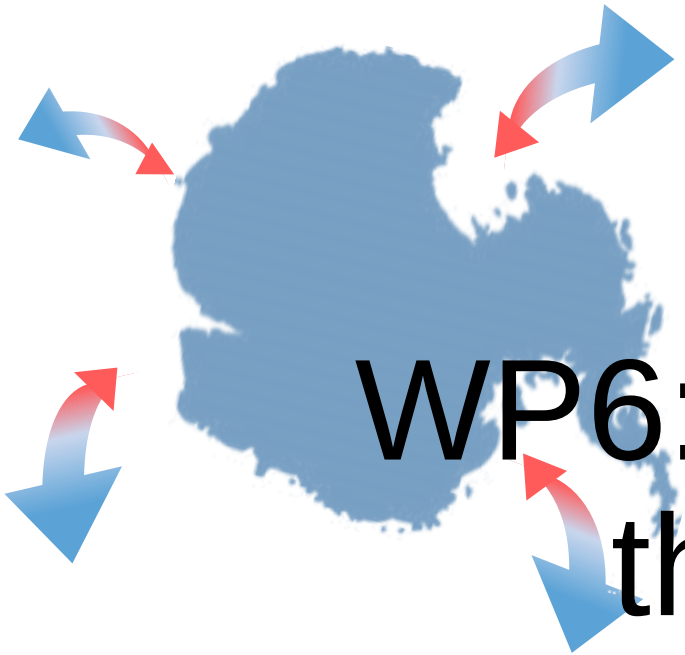
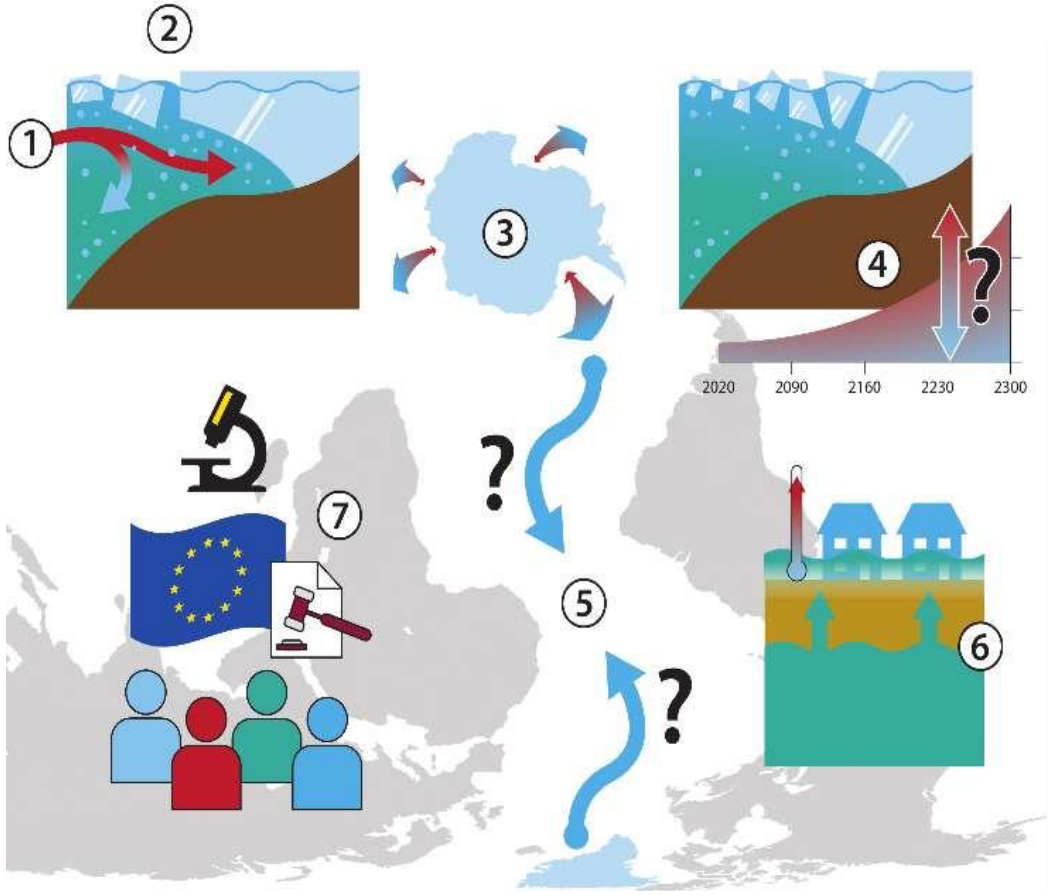


WP6: Role of Antarctica in the global climate: long-term impacts of short-term decision-making

RICARDA WINKELMANN AND TONY PAYNE

WP6 Key objectives



O6 - Assess the ocean impact on, and feedbacks between, key global climate metrics (e.g. SLR, global mean surface temperature) and polar ice sheet melt to 2300 and beyond.

- BISICLES-NEMO to determine spatially and temporally resolved freshwater and iceberg flux fields to then quantify their impact on the global climate system (based on insights and model developments from WP1-5)
- UKESM to assess wider future global impacts and feedbacks upon the AIS up to the year 2300
- PISM-MOM to assess impacts on millennial timescales

The impact analysis will provide an **improved understanding and quantification of potential impacts on global and regional temperatures, SLR and the global ocean circulation and water mass properties**, and specifically include **interactions with other tipping elements** in the Earth System such as the AMOC**.**

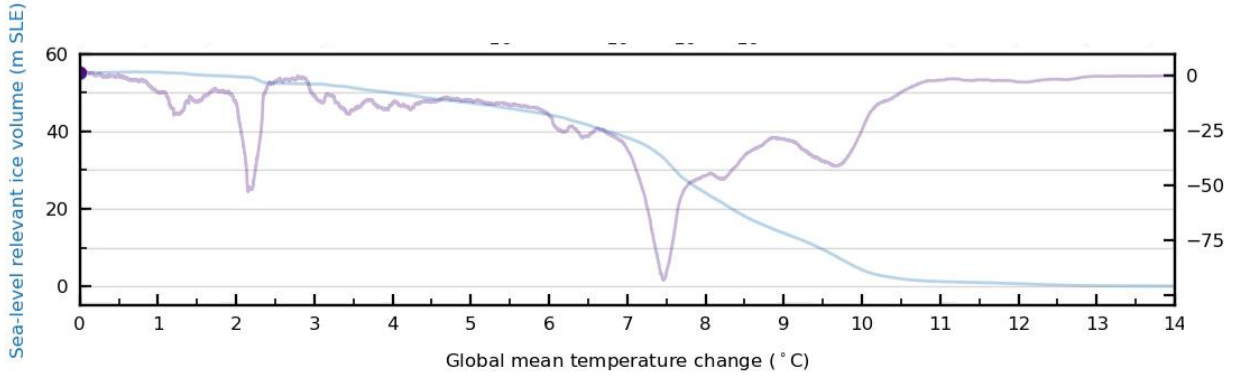
Antarctic Ice Sheet as a tipping element in the Earth System

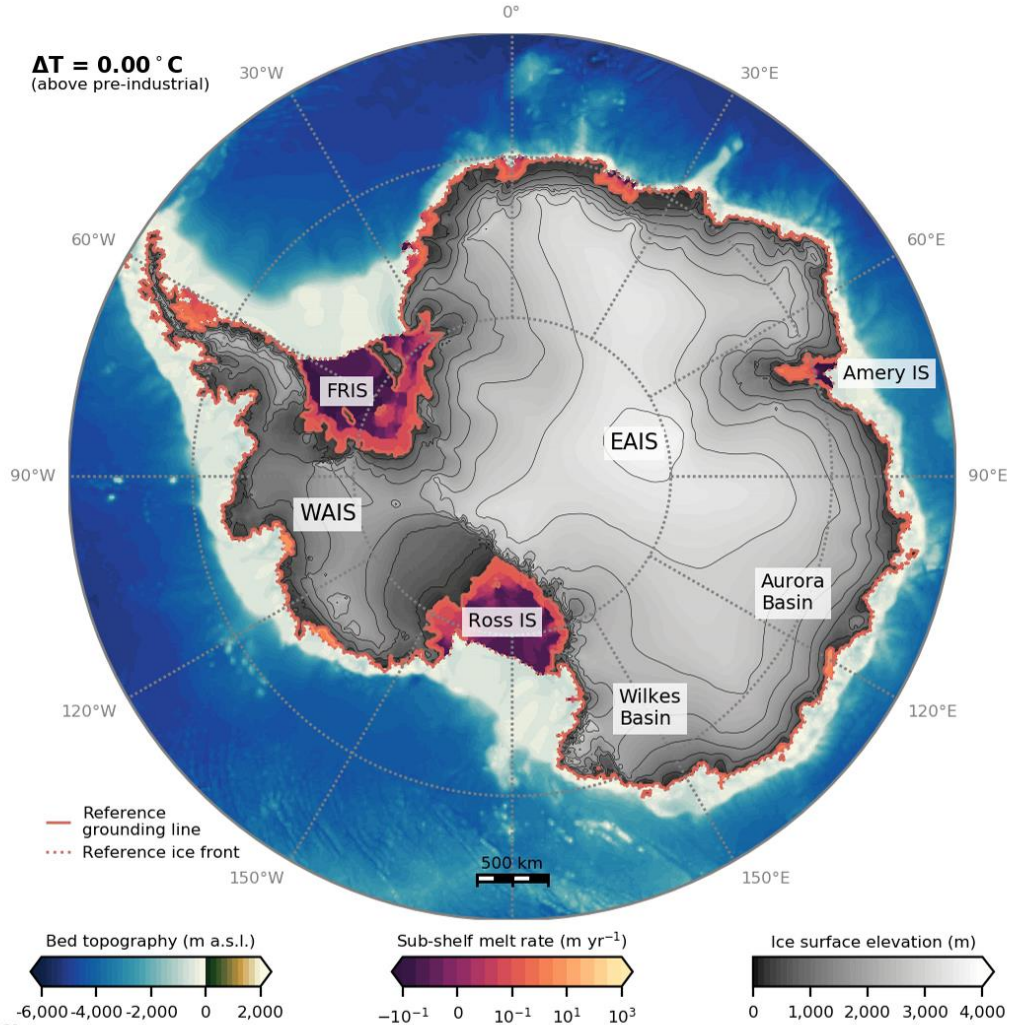
Sequence of tipping points:

First major threshold around 2℃ warming
… collapse of West Antarctic Ice Sheet, mainly driven by ice-ocean interaction

Second threshold at 3 - 6℃ warming
…collapse of East Antarctic marine basins

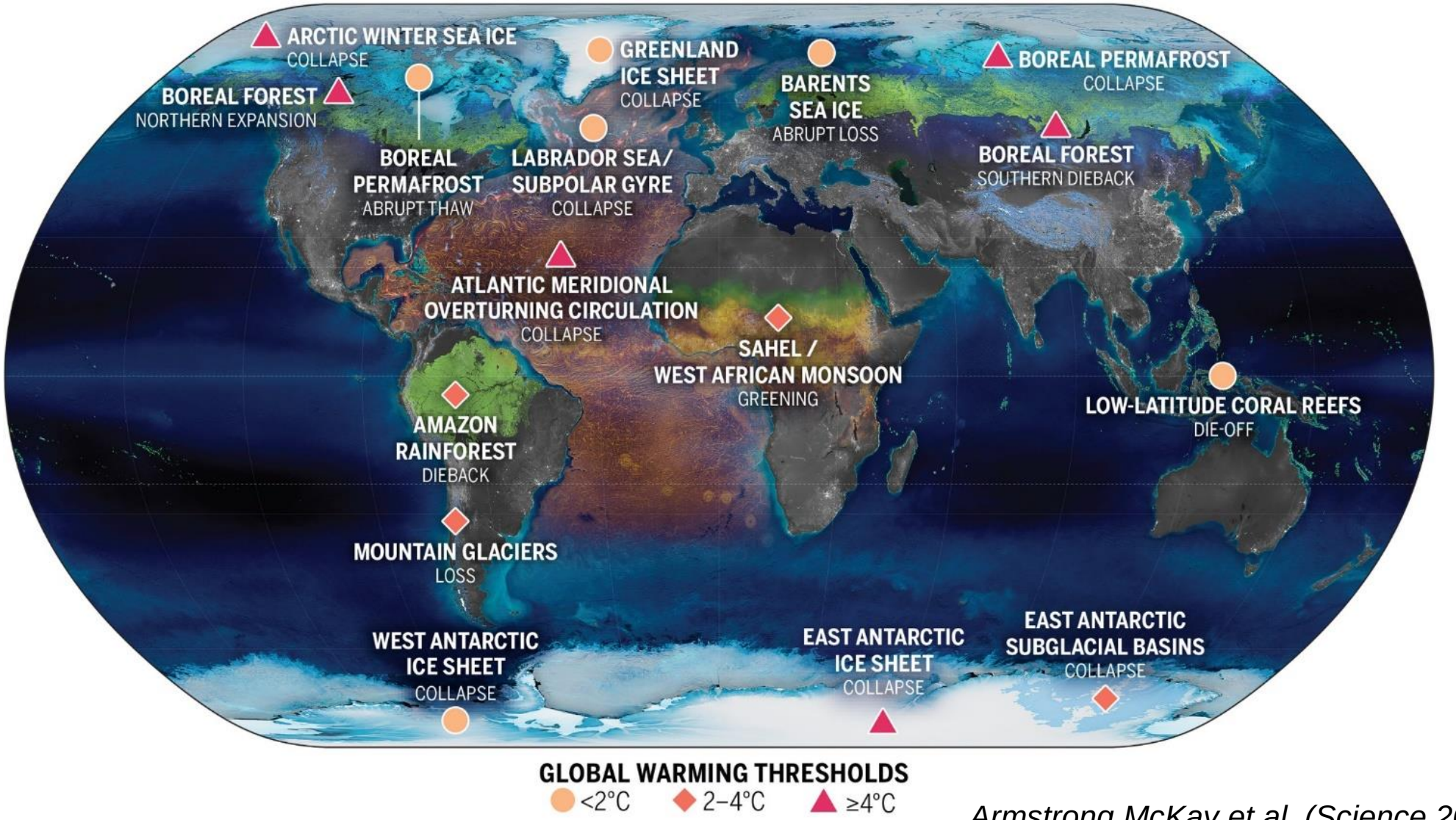
Third major threshold above 6℃ warming
…surface processes become dominant





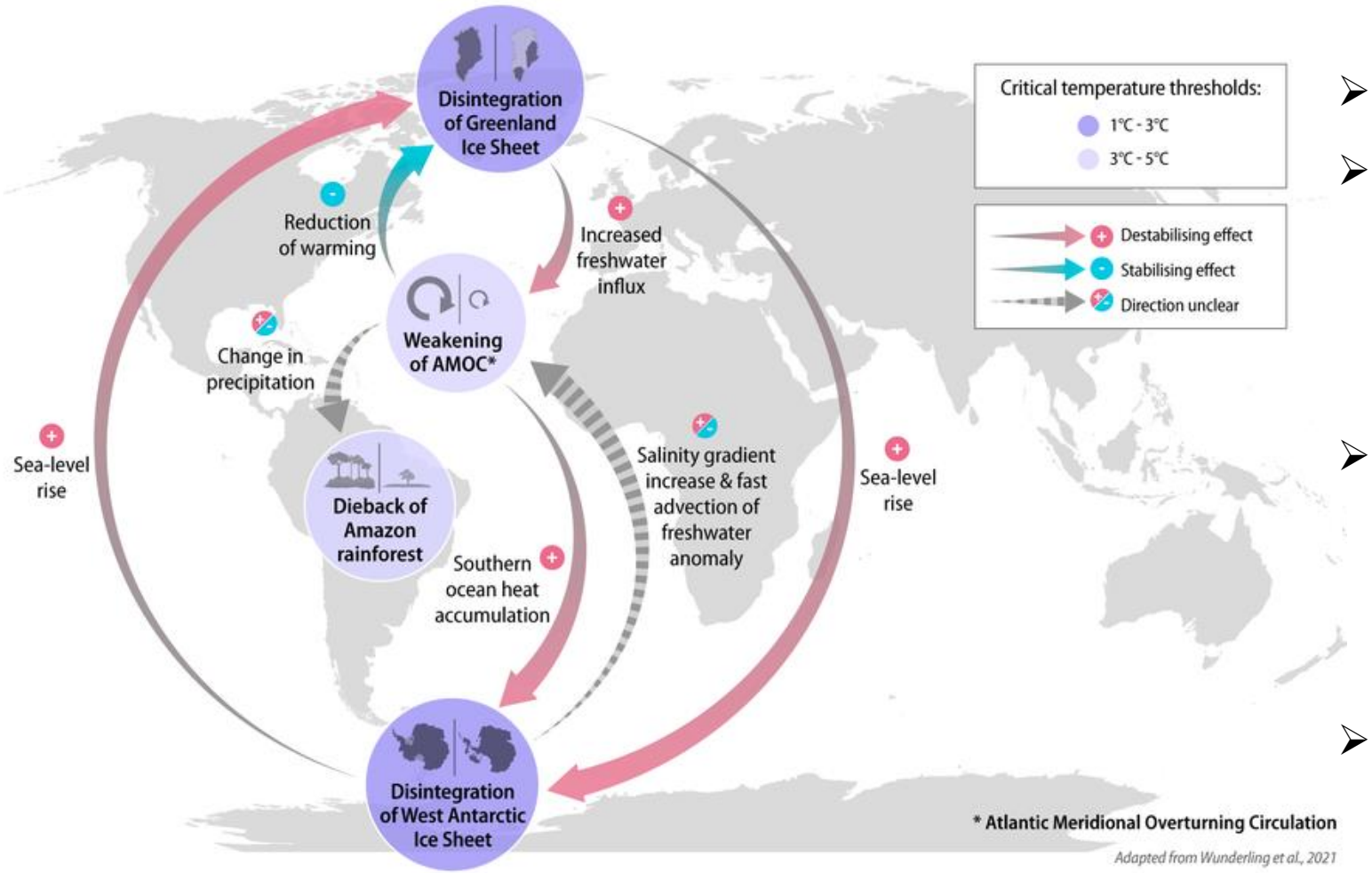
Garbe, Albrecht, Levermann, Donges, Winkelmann (Nature, 2020)

Tipping elements in the Earth System



Armstrong McKay et al. (Science 2022)

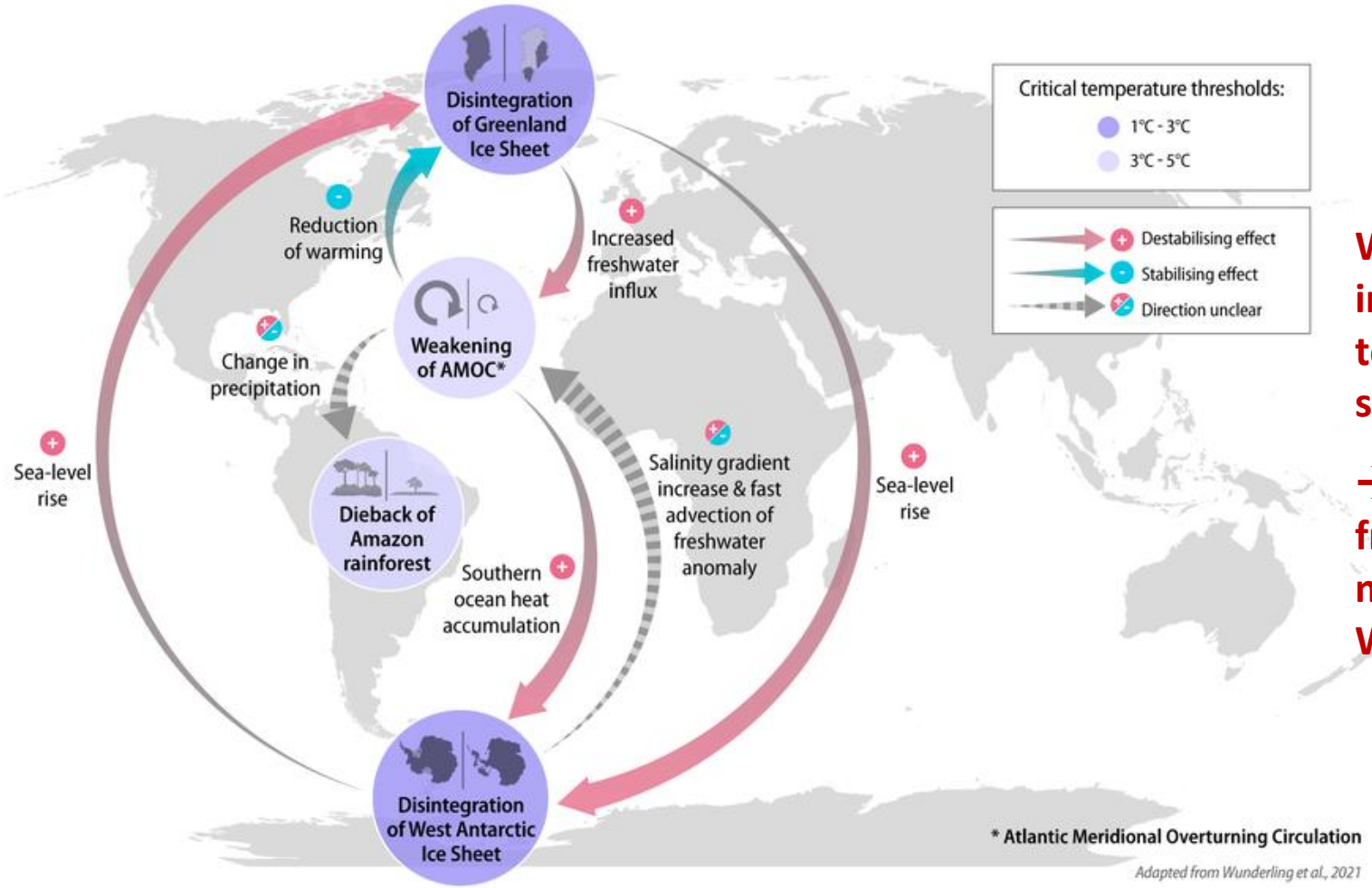
Risk of domino effects?



- Network approach
- Interactions among the Greenland and West Antarctic ice sheets, the Atlantic Meridional Overturning Circulation (AMOC) and the Amazon rainforest
- More than 3 million simulations to propagate the uncertainties in critical temperature thresholds, interaction strengths and interaction structure
- **Risk of domino effects increases significantly with global warming**

Wunderling, Donges, Kurths, Winkelmann (ESD, 2021)
Martin et al. / Ten New Insights in Climate Science (2021)

Risk of domino effects?



WP6 sets out to understand these interactions at a process-level, and to quantify the risks of such large-scale impacts.

→ Need to combine our insights from observations and new modeling approaches based on WP1-5.

Wunderling, Donges, Kurths, Winkelmann (ESD, 2021)
Martin et al. / Ten New Insights in Climate Science (2021)

Task 6.1: Freshwater and iceberg fluxes forcing the global ocean

Lead: UKRI-BAS (P.Holland), partners: UNIVBRIS (T.Payne).

- Incorporating improved iceberg modelling (WP2), determine the fate and local impacts of future fluxes of icebergs and freshwater leaving the AIS in coupled NEMO-BISICLES simulations.
- Projections up to 2300 will examine the impact of freshwater fluxes derived in WP3-4 on large scale ocean circulation including ACC and dense water (Section 1.2.4.3).
- Freshwater feedbacks onto the coupled ice sheet evolution will be emphasised and model higher resolution compliments Task 6.2 (D6.1).

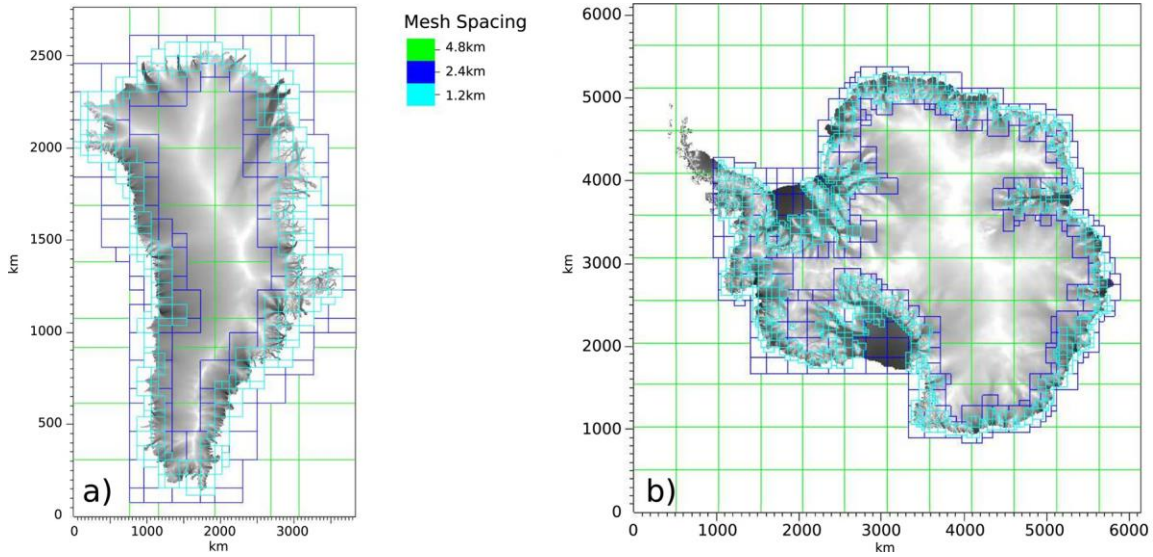
Task 6.2: Earth system impacts to 2300

Lead: UNIVBRIS (T.Payne), partners: UREAD (R.Smith).

- Assess the global impacts and feedbacks of enhanced polar freshwater and iceberg calving (WP2) on future climate using the UKESM coupled with interactive Greenland and Antarctica ice sheets.
- Simulations up to 2300 using the extended socio-economic pathways (SSP) and including scenarios developed in WP4 covering the full range of high-end uncertainties.
- Assessment of the impacts of enhanced freshwater and iceberg calving on a range of global and regional climate indices (e.g. SSH, GMST), emphasising the impacts of ice.

Fully coupled dynamics in UKESM

OCEAN:ICE

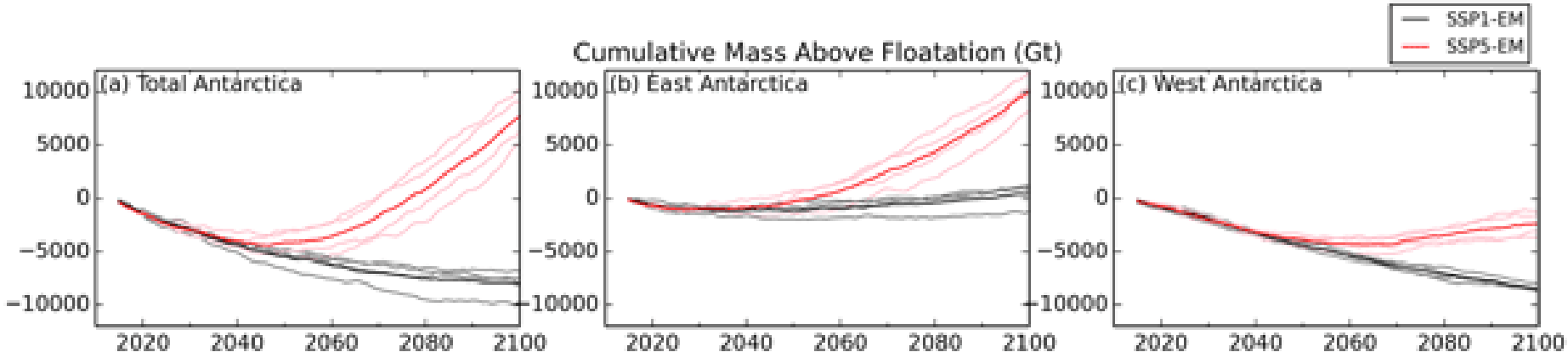


UKESM

… including dynamically coupled ice sheets

Smith et al. (JAMES, 2021)

Antarctic contribution to 21st-century sea-level rise



Siahaan et al. (The Cryosphere, 2021)

Task 6.3: Millennial-scale impacts and potential for tipping cascades

Lead: PIK (R.Winkelmann).

- Centennial and millennial scale runs with coupled PISM-MOM ice sheet-ocean model.
- Assess the dynamics and risk of crossing critical thresholds in atmospheric and oceanic drivers of the ice-sheet dynamics and (rate of) ice loss.
- Model development and analysis contributes to the Tipping Points Model Intercomparison Project (TIPMIP) planning.

WP6 Deliverables

D6.1: Report on coupled export of freshwater and iceberg fluxes from the Southern Ocean to the global ocean to the Southern Ocean with BISICLES-NEMO (M30, UKRI-BAS)

D6.2: Report on impacts of ice loss from Antarctica on global climate and atmosphere until 2300 as simulated with UK-ESM, with a particular focus on impacts on other tipping elements (M45, UNIVBRIS)

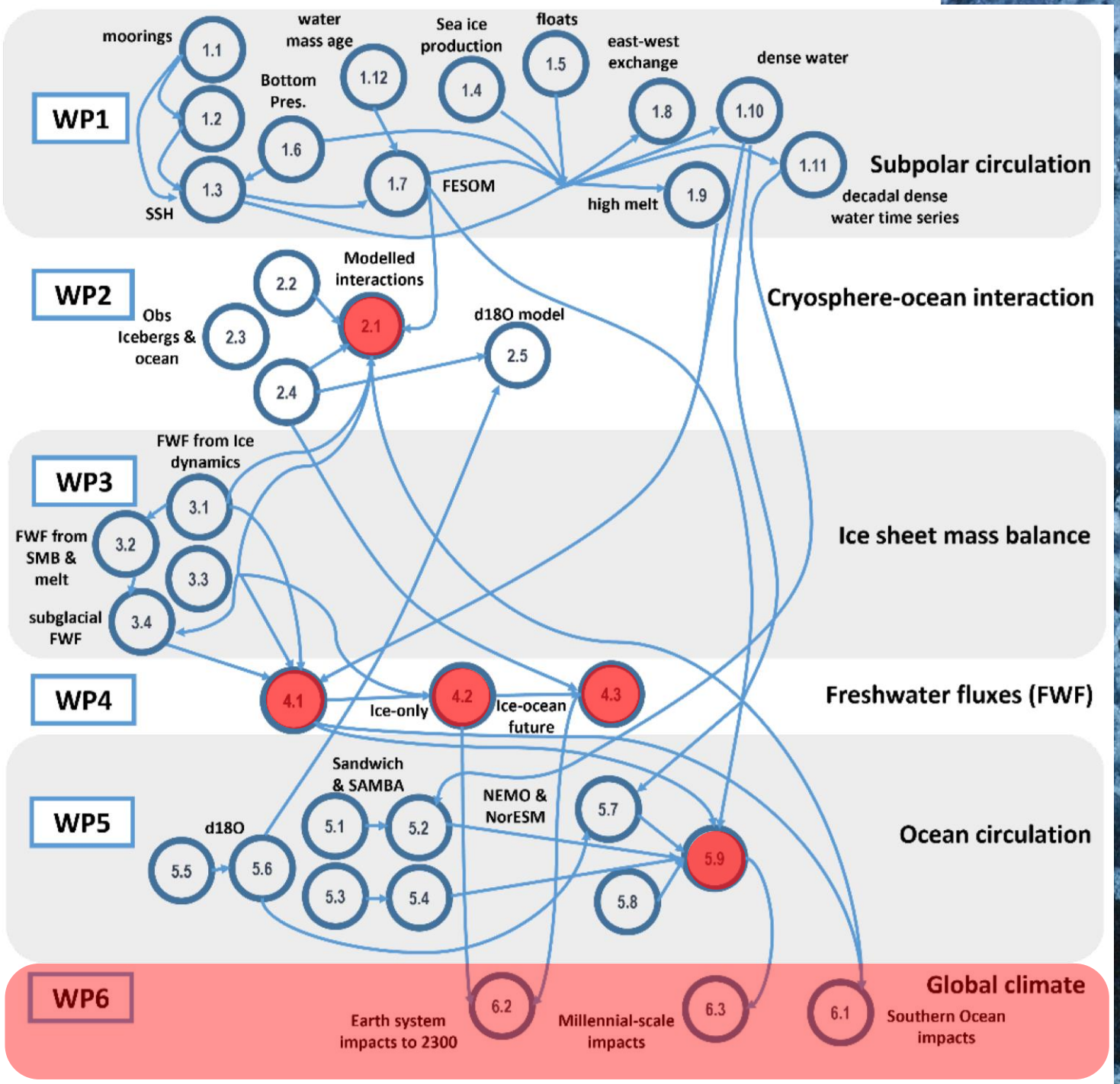
D6.3: Report on impacts of ice loss from Antarctica on the global ocean and sea-level rise on millennial timescales as simulated with PISM-MOM, with a particular focus on impacts on other tipping elements (M45, PIK)

Key links to other WPs

WP2
2.1 Modelling icebergs, bathymetry, and sea ice interactions. (6.1)

WP4
4.1 'Fast-track' sensitivity of freshwater fluxes to climate scenarios (6.1)
4.2 Freshwater fluxes between 2000 and 2300 with robust UQ (6.1)
4.3 Comparison of ice-only to coupled ice-ocean simulations (6.2)

WP5
5.9 Impacts of ice loss ocean on millennial scales (PISM-MOM) (6.3)



WP6 Partners

University of Bristol

Spring 2023 (36 months)

University of Reading

Fall 2024 (24 months)

British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Now
WP2 (15 months),
WP6 (18 months)

PIK

Now (24 months)

+ growing team!

THANK YOU!

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